DOCUMENT RESUME

ED 336 091 IR 015 125

TITLE	National High-Performance Computing and Networking Act. Report To Accompany S. 343, Senate, 102d Congess, 1st Session.
INSTITUTION	Congress of the U.S., Washington, D.C. Senate Committee on Energy and Natural Resources.
REPORT NO	Senate-R-102-64
PUB DATE	23 May 91
NOTE	24p.; Calendar No. 96. For related documents, see ED 332 693-694, IR 015 102-103, IR 015 105, and IR 015 204.
PUB TYPE	Legal/Legislative/Regulatory Materials (090) -- Viewpoints (Opinion/Position Papers, Essays, etc.) (120)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Computer Networks; Databases; Federal Legislation; *Federal Programs; Interaction; National Programs; National Security; *Research and Development; *Technological Advancement
IDENTIFIERS	Congress 102nd; *High Performance Computing; *National Research and Education Network; Supercomputers

ABSTRACT

The purpose of the bill (S. 343), as reported by the Senate Committee on Energy and Natural Resources, is to establish a federal commitment to the advancement of high-performance computing, improve interagency planning and coordination of federal high-performance computing and networking activities, authorize a national high-speed computer network, and authorize high-performance computing activities at the Department of Energy. This report presents an amendment to the bill adopted by the committeee and its recommendation that the bill be passed as amended. The amendment establishes the short title of the bill as the "National High-Performance Computing and Networking Act"; reports the findings of Congress concerning supercomputers and computer networks and their importance to national security, international competitiveness, and technological advancement; presents the purposes of the bill, including interagency planning, coordination, and interaction of federal high-performance computing and networking activities; establishes a National High-Performance Computing and Communications Program (NHPCC); directs the President to establish a high-speed computing network to be known as the National Research and Education Network (NREN); directs the Secretary of Energy to evaluate high-performance computing systems and support computational research and development; allows the heads of federal agencies to exempt programs or activities that involve classified information; and authorizes such funds as may be necessary to carry out the activities authorized by the Act for fiscal years 1992-1996. The report provides background information on high-performance computing, the legislative history of the bill, and discussions of the provisions of the amendment. (DB)

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Calendar No. 96

102D CONGRESS
1st Session

SENATE

REPORT
102-64

ED336091

NATIONAL HIGH-PERFORMANCE COMPUTING AND NETWORKING ACT

MAY 23 (legislative day, APRIL 25), 1991.—Ordered to be printed

Mr. JOHNSTON, from the Committee on Energy and Natural Resources, submitted the following

REPORT

[To accompany S. 343]

The Committee on Energy and Natural Resources, to which was referred the bill (S. 343) to provide for continued United States leadership in high-performance computing, having considered the same, reports favorably thereon with an amendment and recommends that the bill, as amended, do pass.

The amendment is as follows:

Strike out all after the enacting clause and insert in lieu thereof the following:

SECTION 1. SHORT TITLE.

This Act may be cited as the "National High-Performance Computing and Networking Act".

SEC. 2. FINDINGS.

The Congress finds that—

(a) the United States currently leads the world in the development and use of high-performance computing for national security, industrial production, scientific investigation and engineering, but that lead is being challenged by foreign competitors;

(b) advances in high-performance computing and networking are essential to the Nation's defense, international competitiveness, economic prosperity and scientific advancement;

(c) a high-speed national research and education network would provide researchers and educators with needed computer and information resources, and at the same time demonstrate how advanced computers, high-speed networks and data bases can improve the national information infrastructure and act as a test bed for further research and development of high-speed networks;

(d) additional Federal research and development of high-performance computing is necessary for the United States to realize the full benefits of high-performance computing;

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(e) several Federal departments and agencies have ongoing high-performance computing programs, but enhanced interagency planning, coordination and cooperation would maximize the effectiveness of these programs; and

(f) a 1991 report entitled "Grand Challenges: High-Performance Computing and Communications" by the Office of Science and Technology Policy outlines a Federal research and development strategy for high-performance computing, and provides a framework for developing an integrated multi-agency Federal high-performance computing program.

SEC. 3. PURPOSE.

It is the purpose of this Act to help ensure the Federal commitment to the advancement of high-performance computing by—

(a) improving the inter-agency planning and coordination of Federal high-performance computing and networking;

(b) authorizing a high-speed national research and education computer network; and

(c) authorizing Department of Energy high-performance computing activities.

SEC. 4. NATIONAL HIGH-PERFORMANCE COMPUTING AND COMMUNICATIONS PROGRAM.

(a) In order to maximize the effectiveness of the Federal government's high-performance computing efforts the President shall develop and implement a National High-Performance Computing and Communications Program (NHPCC Program).

(b) The purpose of the NHPCC Program is to improve the interagency planning and coordination of Federal high-performance computing and networking.

(c) The NHPCC Program shall—

(1) provide for interagency coordination of Federal high-performance computing research, development, networking and other activities;

(2) establish the goals and priorities for Federal high-performance computing research, development, networking and other activities; and

(3) create a National Education and Research Network.

(d) The President shall submit to the Congress annually a report on the NHPCC Program, which shall include a summary of the activities of the Federal departments and agencies participating in the NHPCC Program.

SEC. 5. NATIONAL RESEARCH AND EDUCATION NETWORK.

In accordance with the requirements of the NHPCC Program, the President shall provide for the establishment of a high-speed computer network, to be known as the National Research and Education Network (NREN), to provide researchers and educators with needed computer and information resources, and at the same time demonstrate how advanced computers, high-speed networks and data bases can improve the national information infrastructure and act as a test bed for further research and development of high-speed networks. The NREN shall—

(a) link Federal departments and agencies, research institutions, educational institutions, industry and others as may be appropriate to promote research and education, and for other purposes as may be appropriate;

(b) be designed, developed and operated in collaboration with all potential users in government, industry, and research and educational institutions;

(c) enable existing Federal and non-federal networks to be linked, to the extent appropriate, in a way that allows autonomy within each component network while maintaining connectivity;

(d) be designed and operated so as to ensure the continued application of laws that provide network and information resources security measures, including those that protect copyright and intellectual property rights, and those that control access to data bases and protect national security;

(e) be developed by purchasing standard commercial transmission and network services from vendors, whenever feasible, and by contracting for customized services when not feasible; and

(f) be designed, developed, and operated in a manner which fosters competition and private sector investment in high-speed data networking.

SEC. 6. DEPARTMENT OF ENERGY HIGH-PERFORMANCE COMPUTING ACTIVITIES.

(a) In accordance with the NHPCC Program, the Secretary of Energy shall—

(1) perform technology development and systems evaluations of high-performance computing systems;

(2) conduct computational research with emphasis on energy applications;

(3) conduct gigabit network applications research, and develop related software tools;

(4) support basic research, education and human resources in computational science; and

(5) provide for networking infrastructure support for energy-related mission activities.

(b) The Secretary of Energy shall establish two High-Performance Computing Research and Development Collaborative Consortia by soliciting and selecting proposals, and is authorized to establish as many more as may be needed. Each Collaborative Consortium shall—

(1) conduct research directed at scientific and technical problems whose solutions require the application of high-performance computing and communications resources;

(2) promote the testing and uses of new types of high-performance computing and related software and equipment;

(3) serve as a vehicle for computing vendors to test new ideas and technology in a sophisticated computing environment; and

(4) be led by a Department of Energy national laboratory, and shall include participants from federal agencies and departments, researchers, private industry, educational institutions and others as the Secretary of Energy may deem appropriate.

(c) The results of such research and development shall be transferred to the private sector and others in accordance with applicable law.

(d) Within one year after the date of the enactment of this Act and every year thereafter, the Secretary of Energy shall transmit to the Senate and House of Representatives a report on activities taken to carry out this section.

SEC. 7. MISCELLANEOUS PROVISIONS.

Except to the extent the appropriate Federal agency or department head determines, the provisions of this Act shall not apply to programs or activities regarding computer systems that process classified information, or computer systems the function, operation, or use of which are those delineated in paragraphs (1) through (5) of section 2315(a) of title 10, United States Code.

SEC. 8. AUTHORIZATIONS.

For fiscal years 1992, 1993, 1994, 1995 and 1996 there are hereby authorized to be expended such funds as may be necessary to carry out the activities authorized by this Act.

PURPOSE OF THE MEASURE

The purpose of S. 343, as reported by the Committee, is to establish a Federal commitment to the advancement of high-performance computing, improve the interagency planning and coordination of Federal high-performance computing and networking activities, authorize a national high-speed computer network, and authorize high-performance computing activities at the Department of Energy.

BACKGROUND

High-performance computing, a definition

A common definition of a supercomputer is simply "the most powerful computer available at any given time." However, the definition of "power" is inexact and depends on many factors, including processor speed, memory size, user skill, the type of job being performed and the type of software used.

The more general term, "high-performance computing," refers to the whole field of advanced computing technologies. These technologies include all types of supercomputers: the traditional types, such as parallel or vector processors; the experimental types, such as large scale parallel processors, neural nets and optoelectronics; and the smaller "minisupercomputers". These technologies also include components of supercomputers that have great impact on the power of the computer: memory, storage devices, input/output devices and software. Very high-speed computer networks are often

linked under the category of high-performance computing because it is through these networks that supercomputers are accessed. Furthermore, the networks themselves require sophisticated computing technology.

Historical development of high-performance computing

The United States invented high-performance computing and continues to lead the world in its development. The biggest single factor accounting for the development of high-performance computing has been the large computational demands required by defense research, particularly in the area of nuclear weapons design.

Historically, the Department of Energy and its predecessor agencies have played the lead role in the development of high performance computing, particularly the supercomputer. Supercomputing originated with what was known as the "Los Alamos problem", the design of the first atomic bomb. In 1945, Los Alamos researchers used the first large-scale electronic computer, the ENIAC, to help solve the Los Alamos problem. Since then, the government has continued to collaborate with supercomputer vendors, such as IBM, Univac (now Unisys), Control Data and Cray Research, making the United States the leader in computational science.

In fact, Cray Research would not exist without the Los Alamos National Laboratory of the Department of Energy. In 1976 Cray offered its first supercomputer to Los Alamos without software or an operating system if the laboratory would develop the technologies needed to operate the machine. The Department of Energy and Los Alamos were instrumental in making the first Cray supercomputer operational. Today, Cray is the biggest manufacturer of supercomputers in the world, and the Los Alamos National Laboratory is the most powerful scientific computing center in the world, serving more than 8,000 researchers throughout the Nation via a computer network.

Much of the Department's research, such as nuclear weapons design or research in high-energy physics, requires the most powerful computers available. In order to carry out the research, DOE has often accelerated the development of high-performance computers by undertaking cooperative activities involving the DOE national laboratories, computer manufacturers, universities, and other Federal agencies. The Department has shaped high-performance computing by acquiring early market and production-model computing systems for its research programs.

The Department's laboratories have become the world's most demanding, sophisticated and experienced users of supercomputers. Manufacturers of high-performance computers routinely send new prototype computers to the DOE national laboratories for testing. The laboratories help the manufacturer identify and solve problems and help in writing the unique software packages supercomputers require.

Today, the Department of Energy remains the biggest user of high-performance computing with over 33 unclassified supercomputers. However, the Department is by no means the only user of supercomputers. Many other agencies within the Federal Government make extensive use of high-performance computing. For example, the Department of Defense has 20 unclassified supercom-

puters, the National Aeronautics and Space Administration has 10, the Department of Commerce has five, and the National Science Foundation has four.

As the federal agencies' high-performance computing demands continue to grow, the need for and benefits of a program to coordinate Federal agency efforts become more apparent.

NEED

Benefits of supercomputers

It has been estimated that a modest Federal investment in high-performance computing would result in over a $300 billion increase to the Nation's gross national product over a 10-year period. Many examples of how high-performance computing have already added to the Nation's economy already exist.

When Airbus, a European consortium, started using supercomputers to help design more efficient airplanes, Boeing and McDonald Douglass were forced to follow. Boeing then used a supercomputer to design a 30-percent more efficient airplane. This savings offset the cost of the supercomputer and helped Boeing to remain competitive.

ARCO used a Cray supercomputer to increase production of its Prudhoe Bay oil field resulting in an additional $2 billion in revenues. ALCOA used supercomputing modeling to reduce the amount of aluminum needed in its aluminum cans by 25 percent. This reduction saved millions of dollars from reduced materials, production, and transportation costs.

Many other scientific endeavors would not be possible without the use of supercomputers. For example, the data we collect from space can only be understood and visualized by a supercomputer. Our understanding of global warming, acid rain, pollution, ozone layer depletion, and the public policy decisions regarding them, will depend on supercomputers. The superconducting supercollider (SSC) will require supercomputers to run the machine and to interpret the data it produces. In fact, almost $400 million of the cost of the SSC will go toward supercomputers. Weather forecasting becomes more accurate the more powerful the supercomputer. The United Kingdom more accurately predicts the weather than the United States because of supercomputers. The human genome project, which is to map all of the genes in the human body, is possible only because of high-performance computers.

Only recently have supercomputers been able to visualize on screen the outcome of experiments. The ability to see the results visually in graphic form is a major step forward in scientific analysis. Without the ability to visualize the results graphically, the researcher must analyze hundreds of pages of computer printouts, which is a painstakingly slow process.

Most of the data this country generates from its scientific endeavors goes unused. Researchers simply do not have the computing resources to analyze all of the data that exist. For example, the data used to discover the ozone hole had existed for 10 years. A researcher looking through that data while working on an unrelated problem inadvertently discovered the ozone hole.

The increased use of high-performance computing will improve productivity in research and development by enabling companies to undertake development which would otherwise be impossible, bring new products and services into the market more quickly and develop better products and services. This improved productivity in research and development equates to increased overall industrial productivity.

Benefits of computer networks

S. 343, as amended by the Committee, would create a National Research and Education Network (NREN) with the capability of transmitting billions of bits of data per second. A Federal commitment to build a national research and education network would accelerate its creation by 5 to 10 years. Government support for applied research can decrease risk, create markets for network technologies and services, transcend economic and regulatory barriers, and accelerate early technology development and deployment. This would not only bolster U.S. science and education, but would also fuel industry research and development and support the market competitiveness of the U.S. network and information services industry.

Researchers were the first to link computers into networks for the purpose of sharing information and broadening remote access to computing resources. The Defense Advanced Research Project Agency (DARPA) created ARPANET in the 1960s to advance networking and data communications and to develop a robust communications network that would support the data conversations of computer scientists. Other Federal agencies soon followed with their own specialized networks for their research communities. Academic and industry users not served by the agency-sponsored networks developed their own networks.

Today, there are thousands of computer networks in the United States. These networks range from temporary linkages between desk top computers over common carriers to institution-wide area networks, to regional and national networks. Some of the services are amateur and poorly maintained, while others are mature information organizations with well-developed services.

Recently, some agencies have pooled funds to support a shared national backbone called the Internet to connect existing networks. The need to connect the users of the networks is the primary reason for the Internet. Just as telephones would be of little use if only a few people had them, a network's usefulness comes with the ability of each network to reach the desks, labs, and homes of its users. Networks expand access to computing resources, data and instruments and allow users to communicate with each other. The payoff comes from connecting people, information, and resources.

Today's networks commonly transmit data at the rate of 1.5 million bits per second, more than a thousand times slower than could be accomplished by the proposed NREN. High data rates are needed to carry out even the most basic scientific studies.

Today, if a scientist wants to study global warming, the data must be physically carried to a supercomputer, processed and then physically returned. A high-speed network would allow that same scientist from anywhere on the network to transmit the data in

seconds, process the data and graphically see the results as the computer is carrying out the study. The scientist could easily change variables in the data and rerun the program as he gains feedback and understanding from the computer.

In order for the NREN to support these and other demanding applications not yet even contemplated, a substantial directed research and development effort is needed in a number of areas such as protocols (the formal structure of inter-computer communications), high-speed computer interfaces for computers, and network equipment such as switches. Multi-gigabit networks represent a change in kind, not just in degree, from today's networks. For example, consider that in a coast-to-coast communication at three gigabits-per-second there are at any instant "in flight" nearly nine megabytes of data, which is more than the memory of most personal computers and workstations.

Some gigabit research has already begun, and several experimental facilities have been established in a productive collaboration of academic, industrial, and governmental organizations, but more federal support will be needed to carry the research program to the stage that commercial providers can use the technology to install and operate a multi-gigabit NREN.

Other countries have also recognized the benefits of high-speed networks. Japan's Nippon Telegraph and Telephone Corporation has announced that it intends to invest $126 billion to install a national fiber optic network which will reach every home, office, and factory in Japan and be capable of transmitting data at the rate of hundreds of millions of bits per second. The Europeans have launched their own initiative to build a high-speed network. Other countries have launched national high-performance computing initiatives.

United States leadership in high-performance computing is being challenged

This bill would provide a strong support base for the development of high-performance computing activities, particularly supercomputers, by requiring the Federal Government to coordinate its activities better. Furthermore, the collaborative research and development consortia established by the bill will help stimulate development of supercomputer by reducing the risk of research and development to United States manufacturers and putting greater supercomputing power into the hands of industry. The need for such support is growing increasingly apparent.

While the United States continues to lead the world in the development of high-performance computing, that lead is being challenged. Some estimate that the Japanese will dominate the supercomputer market in the 1990s, yet the Japanese did not enter the field of high-performance computing until 1983. Today, outside of the United States, Japan is the single biggest market for and supplier of supercomputers. American supercomputers account for less than one-fifth of all supercomputers sold in Japan.

The economic benefits of a strong high-performance computing capability are recognized and pursued by other countries. Some of these countries have launched national efforts to undertake research and development in high-performance computing and to

promote its use. The United Kingdom began implementing a national high-performance computing plan in 1985.

The United States Government currently spends roughly $500 million dollars a year directly on high-performance computing. The current efforts, however, are not coordinated among the individual agencies working on individual projects. As a result, the government's overall effort has been lacking. Federal support is essential if American industry is going to meet the challenge of remaining at the forefront of technology development in this area.

Two years ago, Cray's only American competition in the general-purpose supercomputer market, Control Data Corporation, closed its subsidiary, ETA Systems. Control Data had invested over four hundred million dollars in its supercomputer subsidiary. The company's investment and technology contribution have been lost, including the Nation's only automated supercomputer manufacturing company.

Control Data's inability to sell its supercomputer to the government contributed to the company's failure. Cray Research has enjoyed success largely because Department of Energy laboratories have helped Cray improve its supercomputers and the software for them. Armed with proven supercomputers and the software to run them, Cray has had a much easier time convincing private industry to invest in their supercomputers.

Because of changes in the procurement process, Federal laboratories and agencies have become reluctant to purchase new prototype computers. Faced with this new policy and Cray's established position as industry leader, companies such as Control Data have difficulty entering the supercomputer market.

Though IBM is now trying to reenter the high-performance computing market after a 20-year hiatus, Cray Research remains the United States' only supercomputer manufacturer that can sell the most powerful supercomputers available. Other companies have been formed to develop new types of high-performance computers, but these remain largely experimental.

These experimental designs face large obstacles in becoming viable products in the marketplace. Because of the high capital costs associated with high-performance computers, it is difficult to develop new supercomputers, to build them, and to convince companies to spend anywhere from $1 to $30 million to purchase one. The only way for these companies to succeed is for the Federal Government to purchase their machines.

The need for immediate action

The Federal Government needs to establish its commitment to a national high-performance computing initiative. This need stems from the importance of advancing U.S. research and development critical to U.S. industry, security, and education; the need to strengthen the U.S. computer industry and the need for a national high-speed computer network. To meet these needs, the Federal Government must establish a national high-performance computing initiative that will consolidate and fortify agency plans, devote greater resources to these programs, and catalyze a broader national involvement.

In the last year, high-performance computing has been cited as a critical technology in three major reports dealing with technologies essential to the United States. The three reports which were released by the National Critical Technologies Panel, the U.S. Council on Competitiveness and the Department of Defense, emphasized the importance of high-performance computing to U.S. economic competitiveness, national security and the advancement of scientific knowledge. They call for increased investment by the Federal and private sectors in high-performance computing. The reports also point out that the U.S. is losing its edge in this technology.

In response to a 1986 request by Congress, the OSTP prepared a report on options for high-performance computing. This report has since been revised into an OSTP recommendation for a national high-performance computing initiative. This recommendation was released in September of 1989 and was entitled a "Federal High Performance Computing Program". The initiative calls for an ambitious 5-year research and development program in high-performance computing systems, advanced software and algorithms, a National Research and Education Network (NREN) and long term support for human resources. The OSTP report emphasizes the need for coordination, stable funding, broadened goals, integrated management and increased private sector involvement.

Congress' own Office of Technology Assessment released its interim report on high-performance computing in September 1989. The report calls for immediate and coordinated Federal action to bring together the high-performance computing activities of the Federal Government. The report cites the importance of high-performance computing to our economic security, national security and the scientific community.

Congress, the Executive branch, the research community and the private sector all recognize the wisdom of devoting substantially more resources to high-performance computing for its own sake and for the Federal Government to assume a leadership role in such an effort. Issues related to high-performance computing have been subjected to extensive studies over the last decade. Many committees have been formed, and reports released, all calling for immediate action.

Even the President in his fiscal year 1992 budget requested an increase of almost $150 million for an interagency research and development program called "Grand Challenges: High Performance Computing and Communications." However, the Administration has not clearly established a long-term commitment to a national high-performance computing program as the document outlining the program is silent on the duration of the program. This bill commits the Federal Government to a national high-performance computing initiative for 5 years.

The bill directs the President to provide for the interagency coordination of Federal high-performance computing activities and establish the goals and priorities for them. This ensures that the Federal strategy will build on agency strengths by giving appropriate agencies the responsibilities to coordinate activities in areas of demonstrated capability. It also ensures that the strengths of the other agencies and departments are included by integrating their participation in the various areas.

The expansion of support for Federal high-performance computing activities envisioned by the bill will help extend U.S. technological leadership in high-performance computing and computer communications. This will be accomplished because federal support will reduce the uncertainties, risk and high capital costs associated with the development of new types of high-performance computers.

The bill will spur gains in U.S. productivity and industrial competitiveness by making high-performance computing and networking technologies an integral part of the design and production process. The collaborative efforts called for by the bill between the DOE national laboratories, universities and the private sector will bring greater supercomputing power into the hands of many more researchers.

The NREN component of the NHPCC program will dramatically expand and enhance the U.S. portion of the existing worldwide infrastructure of interconnected computer networks called the Internet. The NREN will provide network access to research and educational institutions at all levels and locations. NREN will be able to interconnect the Nation's educational infrastructure to its knowledge and information centers. Elementary schools, high schools, 2- and 4-year colleges and universities will be able to link together with research centers and laboratories. They will all be able to share access to libraries, databases, and diverse scientific instruments such as supercomputers, telescopes, and particle accelerators.

The bill establishes the kind of Federal commitment needed. The bill creates a long-term national program. The bill builds on Federal programs already in place and provides greater coordination, more resources and extensive private sector involvement. The bill will extend U.S. technological leadership in the development and use of high-performance computing and computer communciations.

LEGISLATIVE HISTORY

Senator Johnston, with Senators Wallop, Ford, Domenici, Bingaman and Craig as cosponsors, introduced S. 343 on February 5, 1991. The bill was referred to the Committee on Energy and Natural Resources. On April 11, the Committee held a hearing on the bill.

A related bill, S. 272, was introduced by Senator Gore on January 24, 1991, and referred to the Committee on Commerce, Science, and Transportation. The Subcommittee on Science, Technology, and Space held a hearing on S. 272 on March 5, 1991. On March 19, 1991, the Commerce, Science, and Transportation Committee ordered S. 272 favorably reported with an amendment in the nature of a substitute.

H.R. 656, a companion bill to S. 272, was introduced on January 28, 1991, and referred to the Committee on Science, Space, and Technology. The Subcommittee on Technology and Competitiveness and the Subcommittee on Science held hearings on March 7, 1991 and on April 10, 1991 on H.R. 656. On May 8, 1991, the Committee ordered H.R. 656 to be reported with an amendment in the nature of a substitute.

During the 101st Congress the Senate Energy and Natural Resources Committee reported S. 1976 which was similar to S. 343 (S. Rept. 101-377). S. 1976 was merged with another bill, S. 1067, on the floor of the Senate and then passed by unanimous consent. The House took no action on the bill.

At a business meeting on May 9, 1991, the Senate Energy and Natural Resources Committee ordered S. 343 favorably reported with an amendment in the nature of a substitute.

COMMITTEE RECOMMENDATIONS AND TABULATION OF VOTES

The Senate Committee on Energy and Natural Resources, in open business session on May 9, 1991, by a unanimous vote of a quorum present, recommends that the Senate pass S. 343, if amended as described herein.

COMMITTEE AMENDMENT

The Committee adopted an amendment in the nature of a substitute to S. 343.

S. 343, as introduced, required the Secretary of Energy to establish a high-performance computing program. As part of the program, the Secretary was instructed to establish a national high-speed computer network, promote education and research in high-performance computational science and establish at least two collaborative research and development consortia.

The amendment requires the President to establish a national high-performance computing program. As part of the program, the President is directed to provide for the interagency coordination of Federal high-performance computing activities, establish the goals and priorities for Federal high-performance computing activities and establish a National Research and Education Network. The amendment also directs the Secretary of Energy to undertake computational research, develop and evaluate high-performance computing systems, conduct gigabit network research, provide networking infrastructure support for energy-related mission activities, and establish collaborative research and development consortia.

National high-performance computing and communications program

The amendment directs the President to develop and implement a National High-Performance Computing and Communications Program (the "NHPCC Program"). As part of the NHPCC Program, the President is directed to provide for the interagency coordination of Federal high-performance computing research, development, and networking activities. The 1989 OSTP report provides a framework for such a coordinated program. The President in this year's budget request seeks to implement a national program for 1992 similar to the one outlined in the OSTP report.

The OSTP report and the President's 1992 program were both developed through the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) which is composed of representatives of all the Federal agencies. The FCCSET process allows for interagency dialogue, provides internal checks and balances

and is an appropriate vehicle for developing and coordinating a balanced national program.

Both the OSTP report and the President's 1992 program specify specific activities and agency roles. The legislation is intentionally silent on specific agency roles and activities, because of the rapidly changing nature of this technology, agency roles and responsibilities may need to be changed. Should the need to change agency roles and responsibilities arise, the amendment allows, and the committee would expect, that the roles and responsibilities would be changed.

For example, the 1989 OSTP report recommended that certain agencies be assigned lead roles in various activities. However, what was meant by lead agency was not at all clear and led to considerable confusion. The President's proposed program for 1992 makes no reference to lead roles, but rather assigns coordinating functions to certain agencies. Should legislation have codified the lead agency concept, agencies would have been given responsibilities and authority that was not meant for them, or which may have become inappropriate for them in the future. Furthermore, there will be significant oversight by Congress in the implementation of the program thereby limiting the need for specificity.

The Committee, however, has specified certain activities for the Department of Energy which are to be undertaken in accordance with the NHPCC program. The Department historically has used high-performance computing to support its mission needs. The Committee believes high-performance computing is so important to the Nation's well-being that high-performance computing should be a mission for the Department. The Department is the largest user of supercomputers and is strongly situated to help the country retain its technological leadership. While the amendment does activities for the Department, the language used is very broad and gives the Administration a great deal of flexibility in structuring the Department's activities.

The amendment is intentionally silent on the kinds of technology to be supported, stressing, instead, that the NHPCC and related activities need to be driven principally by the government's proper role as user and customer, rather than developer, of commercial technologies. While an important part of the NHPCC will continue to be sponsoring of research into novel computer system architectures, agencies should ensure that sponsorship during the precompetitive stage does not translate into actual or de facto advocacy of the sponsored products, thus discouraging private investment in purely commercial ventures. Furthermore, because of the national importance of this initiative, the Committee believes it important that all types of high-performance computing technology be supported.

While massively parallel computer architectures offer promise for huge gains in computational speed and power for certain applications, there are also new types of vector processors and competing parallel solutions, both developed commercially, which offer similar promise for other applications. Also other experimental concepts should be pursued such as with optoelectronics and neural nets. By remaining silent, the amendment places no one technology over any other. The agencies in carrying out the NHPCC program

should likewise place no more importance of one technology over another.

Under the President's 1992 program, FCCSET's role in the program is limited to making recommendations for agency roles and responsibilities. Neither FCCSET or the OSTP will be directed by this legislation to implement the program. Under the amendment, only the President has the authority to implement the program. While FCCSET may continue to make recommendations, only the President can assign specific roles and resonsibilities to agencies.

Once the President has assigned agency roles and responsibilities, it will be up to the individual agencies to carry out their respective responsibilities. The amendment grants the President the authority to make these delegations and gives the agencies the authority to carry out NHPCC Program activities. This will also allow Congress to influence the individual agency assignments in the NHPCC program through the annual appropriations process.

The amendment calls for the establishment of goals and priorities of Federal high-performance computing research, development and networking activities. The amendment envisions a 5-year program. Part of developing such goals and priorities would include establishing the expected funding levels for the relevant agencies and activities over the next 5 years. Of course, it will not be possible to identify in the program plan all of the contributions each of the agencies will contribute.

For example, while the National Security Agency makes extensive use of high-performance computing, much of their work is classified. Also, the Department of Energy's direct contributions to the national program will come from the energy side. However, the Department's high-performance computing defense activities will contribute to the program. Since these activities are funded on the defense side, they will not appear as a direct part of the national program.

A successful high-performance computing initiative by the Federal Government requires cooperation between all Federal agencies with each agency contributing to the initiative from their respective areas of expertise. With the rapidly changing nature of this technology, agencies' expertise may well change. The amendment calls for a balanced, national program while allowing flexibility to make changes should the need to do so arise.

National Research and Education Network (NREN)

The amendment directs the President to establish a high-speed computer called the National Research and Education Network (NREN). NREN will expand and enhance the U.S. portion of the existing worldwide infrastructure of interconnected computer networks the Internet, enabling government, research institutions, industry, educational institutions and others to link together. A large portion of the domestic Internet is supported and loosely coordinated by Federal agencies, principally DARPA, DOE, NASA and NSF.

The Administration is in the process of establishing a Federal Network Council. The purpose of the Council is to oversee the evolution and operation of the Internet into the NREN. The Council is composed of representatives of virtually all of the Federal agencies. The Council will be advised by a panel composed of representatives

of many of the constituencies expected to be served by the NREN. The amendment adopted by the Committee allows this management structure to continue, but mandates a number of requirements.

Section 5(a) stipulates that the NREN be designed in collaboration with all potential users of the NREN. Potential users of the NREN include the computer and telecommunication industries, the education community, researchers, librarians, Federal agencies and information service providers. A number of potential users of the NREN have expressed concern that they lack a voice in the design and operation of the NREN. This stems from the fact that the Federal Network Council does not have any representatives from outside the Federal Government. The only input the Council receives comes from the advisory body which does not contain representatives from all of the potential constituencies of the NREN. While many of the users of the NREN are known today, not all are. So, rather than specify who is to help in the design and operation, the amendment simply directs that all potential users be represented. However, the requirement is only generic in nature. It does not require every potential user to be consulted, only appropriate representatives of the various types of potential users need to be consulted.

The Federal Network Council is a body that will likely evolve. It is the understanding of the Committee that at some point in the future the Council will evolve into a body having direct representation from all of the NREN constituencies rather than just being a Federal body. So, the constituencies currently only having input through the advisory body will have a more direct voice in the operation of the NREN. The amendment gives the President the authority to create such a Council or any other management entity the President believes necessary to create and operate the NREN. One very important reason that each of the constituencies be represented is that many of them will be providing part of the networking services that form the NREN.

Section 5(c) of the amendment directs that existing Federal and non-Federal networks be linked to the extent appropriate in a way that allows autonomy within each network. Network autonomy is critical to many of these constituencies, particularly the Federal ones. Agencies such as the Department of Energy use networks to fulfill their mission requirements. The Department's networks must have certain bandwidth and security requirements, a certain degree of reliability and be able to assure that particular users have access. Section 5(c) assures the Department and any one else that becomes involved with the NREN that they exclusively control their own individual networks.

The intent of the amendment is to accelerate the development of networks by the private sector and not replace private sector functions. Section 5(e) and (f) accomplish this. Section 5(e) requires that commercial network services be purchased whenever feasible. Section 5(f) stipulates that the NREN be designed in a manner that fosters competition and private sector investment. Only when standard commercial services are inadequate should customized services be contracted for. Even then, the private sector can often meet these customized needs. However, if private sector services

are inadequate, the amendment in no way precludes agencies from designing and operating portions of the NREN themselves. The amendment simply requires that the private sector be used as much as possible in designing and operating the NREN.

Department of Energy Activities

Section 6 directs the Secretary of Energy to undertake a number of high-performance computing activities, but is to do so in accordance with the President's NHPCC program. The Committee intentionally made the activities very broad. It is anticipated that the Department will participate in all components of the NHPCC program. However, the amendment places special emphasis on a number of areas.

Section 6(a)(1) directs the Secretary to perform technology development and systems evaluation of high-performance computing systems. Because of the Department's large computational demands, the Department has historically performed this function and is well equipped with the personnel and know how to continue to do so. Section 6(a)(3) directs the Secretary to conduct gigabit network applications research. While other agencies will carry out gigabit network research, the Department already runs its own network and carries out high-speed network research.

Aside from the particular high-performance computing activities the Department will perform in the NHPCC Program, the amendment directs the Secretary to establish Collaborative Research and Development Consortia.

COLLABORATIVE RESEARCH AND DEVELOPMENT CONSORTIA

The amendment directs the Secretary to establish at least two Collaborative Research and Development Consortia (CRDCs) among industry, Federal agencies and departments, researchers, educational institutions, and others as appropriate.

The exact number depends largely on the size of the CRDCs established, the cost of each, and the amount of funding available. As the Secretary gains experience with the CRDCs, the Secretary has the flexibility to create more CRDCs and change the structure or activities of them. The CRDCs will directly support the goals of this legislation by helping to shape high-performance computing technology, and by putting more useful computing power into the hands of U.S. industry, higher education and broader segments of the population.

Building on current models

DOE and its laboratories are in a position to help the U.S. maintain its leadership, strengthen the U.S. computing industry, and encourage deployment of high-performance computing in analysis, design, concurrent engineering, and manufacturing for U.S. industry. In the past, the Department accomplished this role almost entirely with the financial support of the nuclear weapons research, development, and testing program. That is no longer appropriate, nor possible, today. The Department's contributions now extend to a much broader spectrum from the human genome project to en-

hanced oil recovery. From these new applications the Department can continue to shape high-performance computing.

The Department of Energy's Advanced Computing Laboratory (ACL) at Los Alamos National Laboratory provides a prototype CRDC. The ACL acts as a catalyst by collaborating with industry to conduct research in three key technology areas: real-time visualization, high-speed networking and software for sophisticated scientific computer programs.

The ACL also serves as the primary interface for Los Alamos laboratory participation in several other activities: the DOE/Applied Mathematical Sciences Advanced Computing program, the NSF Science and Technology Center for Research on Parallel Computation (a consortium of Rice University, Caltech, Los Alamos, and Argone), and the Gigabit National test bed.

The need to solve a broad spectrum of applications drives the activities of the ACL. Los Alamos' ACL provides an excellent example of an existing center of excellence in high-performance computing that is positioned to participate in the development of computing technology through the NHPCC Program. Unlike other federal computing technology research programs, such as those at the National Science Foundation and DARPA, the ACL is application and user-driven. This feature is fundamental to the intent of the CRDC, which is intended to provide a market incentive to commercial development of both high-performance computing systems and applications.

CRDC structure

The amendment requires that the Secretary establish each CRDC by soliciting and selecting proposals. This will establish a competitive atmosphere generating a number of proposals for the Secretary to select from.

A DOE national laboratory will lead each CRDC. While the lead DOE National Laboratory has responsibility for the direction and performance of the consortium, the other participants from industry, universities, and the Federal sector will also carry out CRDC activities. Thus, not all of the many activities the CRDC will perform will necessarily take place at the geographic location of the lead DOE National Laboratory. Most likely, the participants will be spread out through the country. Each of the participants will have their own specific task assigned to them. Geographically distributed participants allow the CRDCs to develop advanced prototype networks, promote technology transfer, and involve more individuals from diverse backgrounds.

CRDC activities

Just as with the activities of the ACL, the need to solve a broad spectrum of applications will determine the activities of each CRDC. The amendment requires that each CRDC conduct research directed at scientific and technical problems whose solutions require the application of high-performance computing resources. In the same way that the DOE laboratories have provided the "pull" for high-performance computing technology from the computing industry in the past because of the intense computational demands of the nuclear research program, the CRDCs, will challenge high-per-

formance computing vendors to continue pushing the state of the art through other computation-intensive scientific problems.

The amendment requires that the CRDCs serve as vehicles for testing new technology in a sophisticated computing environment. Los Alamos' ACL illustrates how a CRDC can serve as such a vehicle. The ACL has helped Thinking Machines, Inc., develop a second generation Connection Machine. Scientific problems requiring intense computational resources test the Connection Machine's performance. This collaboration between the laboratories and industry will help computing vendors understand what products will be needed next, and help industrial users to learn what high-performance computers can do for them.

The CRDCs could help to establish the NREN required by the amendment. The CRDCs could undertake research and development of advanced prototype networks in helping to establish the NREN. Since the NREN will require sophisticated software applications, CRDCs would be an excellent resource in helping to write the software. Both hardware and software development are ideal activities for the CRDCs to undertake.

Section 6(c) requires that the results of research be transferred to the private sector. The amendment does not specify the exact mechanisms to accomplish this but rather leaves the choice of mechanism to the Secretary. There are a variety of mechanisms available to the Secretary to accomplish the technology transfer. For example, the CRDCs may be established through a Cooperative Research and Development Agreement as provided for in the National Competitiveness Technology Transfer Act of 1989 (15 U.S.C. 3710a). This gives the Secretary the flexibility to choose the technology transfer mechanisms most appropriate for each of the CRDCs.

The Secretary may devise new types of technology transfer mechanisms, such as an industrial user program. For example, high-performance capabilities might be made available through high-speed networks to industries who have been reluctant to make use of high-performance computers. Demonstration programs of the value of high-performance computing to businesses, schools and universities might also be utilized.

S. 343 as introduced expressly afforded the antitrust protection of the National Cooperative Research Act of 1984 (15 U.S.C. 4301-4305). The amendment deletes the reference because this Act clearly applies to the activities of the CRDCs.

Ownership of inventions and creations

S. 343 as introduced contained three intellectual property provisions. The amendment does not contain any intellectual property provisions. The first intellectual property provision contained in S. 343 required that title to any invention or software creation, a defined term, vest in the United States and be governed by the provisions of 42 U.S.C. 5908, unless otherwise provided by law. This provision addressed a gap in the law.

The only protection afforded to inventors of software is a copyright. However, under current law the government may not obtain protection through the copyright laws. Without an express provision granting title, who owned software when government funds

were involved would not be clear. S. 343 closed this gap by investing title to "software creations" in the government. S. 343 then granted the generic authority provided under 42 U.S.C. 5908 to the Secretary to deal with the rights to the software. However, to the extent another law would specifically have governed title or the allocation of property rights to inventions, that other law would apply.

S. 343 also prohibited the disclosure of trade secrets, or commercial or financial information. Without this protection, non-Federal parties are reluctant to participate in research activities with the Federal Government. S. 343 also prohibited disclosure of information brought in by non-Federal parties as well as information that is developed as a result of the research activities.

The amendment deleted all three intellectual property provisions. This was done by request of the Administration. Particularly with respect to the software provision, the Administration wanted more time to study the issue. While the gap in the law dealing with software remains, the protection afforded by the latter two intellectual property provisions may be obtained through the use of other laws such as the National Competitiveness Technology Transfer Act of 1989 (15 U.S.C. 3710a).

Authorization

The amendment envisions a 5-year program and authorizes such funds as are necessary to carry out the activities authorized by the Act for each of the years 1992, 1993, 1994, 1995 and 1996.

SECTION-BY-SECTION ANALYSIS

Section 1 establishes the short title as the "National High-Performance Computing and Networking Act".

Section 2 contains the findings of Congress. High-performance computing and networking are essential to the Nation's defense, international competitiveness and scientific advancement. Though the United States leads the world in the development and use of high-performance computing, that lead is being challenged by foreign competitors.

Section 3 contains the purposes of the bill. It is the purpose of the bill to ensure a Federal commitment to the advancement of high-performance computing by improving the interagency planning and coordination of Federal high-performance computing and networking activities, authorizing a national high-speed computer network and Department of Energy high-performance computing activities.

Section 4 establishes a National High-Performance Computing and Communications Program (NHPCC Program). The program is to provide for interagency coordination of Federal high-performance computing activities, establish the goals for Federal high-performance computing activities and create a national high-speed research and education computer network.

Section 5 directs the President to establish a high-speed computer network to be known as the National Research and Education Network (NREN). The network will link Federal departments and agencies, research institutions, educational institutions, and indus-

try as may be appropriate. The network will provide researchers and educators with access to computers, data bases and high-performance computers.

Section 6 directs the Secretary of Energy to evaluate high-performance computing systems, conduct computational research, carry out gigabit network applications research, support basic research and education in computational science and provide networking infrastructure support for energy-related mission activities.

The Secretary is to establish at least two High-Performance Computing Research and Development Collaborative Consortia. Each Consortium is to conduct research directed at scientific and technical problems whose solutions require the application of high-performance computing and communications resources; promote the testing and uses of new types of high-performance computing and related software and equipment; serve as a vehicle for computing vendors to test new ideas and technology in a sophisticated computing environment; and be led by a Department of Energy national laboratory with participants from Federal agencies and departments, researchers, private industry, educational institutions and others as the Secretary of Energy may deem appropriate.

Section 7 allows the heads of Federal agencies to exempt programs or activities that involve classified information.

Section 8 authorizes such funds as may be necessary to carry out the activities authorized by the Act for fiscal years 1992, 1993, 1994, 1995 and 1996.

COST AND BUDGETARY CONSIDERATIONS

The following estimate of the cost of this measure has been provided by the Congressional Budget Office:

U.S. CONGRESS,
CONGRESSIONAL BUDGET OFFICE,
Washington, DC, May 20, 1991.

Hon. J. BENNETT JOHNSTON, Jr.,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR MR. CHAIRMAN: The Congressional Budget Office has prepared the attached cost estimate for S. 343, the High-Performance Computing and Networking Act. Enactment of S. 343 would not affect direct spending or receipts. Therefore, pay-as-you-go procedures would not apply to the bill.

If you wish further details on this estimate, we will be pleased to provide them.

Sincerely,

ROBERT D. REISCHAUER,
Director.

CONGRESSIONAL BUDGET OFFICE—COST ESTIMATE

1. Bill number: S. 343.
2. Bill title: The High-Performance Computing and Networking Act.

3. Bill status: As ordered reported by the Senate Committee on Energy and Natural Resources, May 9, 1991.

4. Bill purpose: S. 343 would establish a National High-Performance Cumputing and Communications Program (NHPCC Program) for interagency coordination of federal activities in high-performance computing. As part of this effort, the President would establish a high-speed computer network, designated the National Research and Education Network (NREN), to provide researchers and educators with need computer and information resources.

S. 343 would require the Department of Energy (DOE) to evaluate high-performance computing systems and conduct other activities in support of the NHPCC program. The bill would authorize appropriations to DOE of amounts necessary to conduct activities required by the bill.

5. Estimated cost to the Federal Government:

[By fiscal year, in millions of dollars]

	1991	1992	1993	1994	1995
Estimated authorization level	93	110	138	157	168
Estimated outlays	42	87	120	142	159

In addition to the DOE funding authorized in S. 343, other agencies would incur costs to implement the bill's objectives, which encompass the development of an integrated multi-agency federal high-performance computing program. A companion bill, S.272, as ordered reported by the Senate Committee on Commerce, Science, and Transportation on March 19, 1991, would authorize spending on high-performance computing by the National Science Foundation (NSF), the National Aeronautics and Space Administration (NSAS), and the National Institute of Standards and Technology (NIST). The Defense Advanced Research Projects Agency (DARPA) would also contribute to the high-performance computing program.

The bill has adopted goals and strategies for the NHPCC program that are roughly in line with proposals from the Administration, as reported by the Office of Science and Technology Policy and proposed in the President's 1992 budget. The Administration's proposals would involve total spending by various agencies of over $4 billion during the 1992–1996 period. Some of the activities mandated by both S. 343 and S. 272 are already underway.

The costs of S. 343 fall within budget function 270.

Basis of estimate: The estimates of DOE authorization levels are based on the Administration's five-year plan for high-performance computing. This estimate assumes that the full amounts estimated would be appropriated for each fiscal year. The estimated outlays are based on historical spending patterns for similar DOE research and development activities.

CBO expects that fees for use of the high-speed computing network would be phased in once the network is operating, which would probably be in 1994 or later. Receipts from these fees could ultimately provide a significant offset to the operating costs of the network. Nevertheless, we do not expect that receipts would be significant during the five-year period covered by this estimate.

6. Pay-as-you go considerations: The Budget Enforcement Act of 1990 sets up pay-as-you-go procedures for legislation affecting direct spending or receipts through 1995. CBO estimates that enactment of S. 343 would not affect direct spending or receipts. Therefore, pay-as-you-go procedures would not apply to this bill.

7. Estimated cost to State and local governments: None.

8. Estimate comparison: none

9. Previous CBO estimate: On April 5, 1991, the Congressional Budget Office transmitted a cost estimate of S. 272, as ordered reported by the Senate Committee on Commerce, Science, and Transportation on March 19, 1991. S. 272 is a companion bill to S. 343; the former would authorize appropriations to NSF, NASA, and NIST, while this bill would authorize appropriations only to DOE.

10. Estimate prepared by: Peter Fontaine.

11. Estimate approved by: C.G. Nuckols (for James L. Blum, Assistant Director for Budget Analysis).

REGULATORY IMPACT EVALUATION

In compliance with paragraph 11(b) of rule XXVI of the Standing Rules of the Senate, the Committee makes the following evaluation of the regulatory impact which would be incurred in carrying out S. 343.

The bill is not a regulatory measure in the sense of imposing government-established standards or significant economic responsibilities on private individuals and businesses. The bill contains authorizations for a national high-performance computing program, a national research and education computer network, and a research and development program within the Department of Energy. Any involvement of private firms and individuals in these activities is voluntary.

No personal information would be collected in administering the program. Therefore, there would be no impact on personal privacy from the bill.

Little, if any, additional paperwork would result from the enactment of S. 343.

EXECUTIVE COMMUNICATIONS

The pertinent legislative report and communication received by the Committee from the Office of Science and Technology Policy setting forth Executive agency recommendations relating to S. 343 are set forth below:

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
Washington, DC, May 17, 1991.

Hon. J. BENNETT JOHNSTON,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR CHAIRMAN JOHNSTON: I understand that the Committee on Energy and Natural Resources has recently marked up S. 343, the "Department of Energy High Performance Computing Act." I appreciate the interest of the Committee in the High Performance Computing and Communications (HPCC) Program, which will have

dramatic benefits for scientific and technological research, competitiveness, education, and other areas. My staff and I have carefully reviewed the proposal bill and would like to offer our comments.

As you know, S. 343, as amended, is one of three pending bills on the President's initiative in high-performance computing and communications. In reviewing the proposed legislation, we have relied on certain principles that we find useful in assessing the potential effects of these bills on the HPCC program. I would like to begin our comments on S. 343, as amended, with an explanation of these principles.

First, we believe that while separate legislation is not required, the primary objective for any legislation in this area should be to provide congressional endorsement and guidance for the HPCC program. This is best achieved by a clear enunciation of the goals and purposes of the HPCC program without detailed legislative specifications of the functions of the program or the assignment of agency responsibilities. As a cohesive interagency R&D initiative, HPCC is still in the process of being launched. However carefully planned, the program is almost certain to undergo significant evolution in both function and responsibilities in response to both operational experience and the dynamic of scientific and technological change. To cast the program in concrete before it is implemented would be unwise.

Secondly, we believe that any congressional mandates regarding the interagency coordination process should be carefully avoided. The success of the cooperative effort under the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) and the coordinating role of the Office of Science and Technology Policy (OSTP) has depended critically on the delicate balance achieved by the agencies between their individual mission responsibilities and their collective shared purpose. This balance has been achieved voluntarily and in an atmosphere entirely free of coercion. To give OSTP or FCCSET management responsibility or enforcement authority, or to assign specific coordinating or "lead agency" responsibilities to the agencies would be counterproductive and inappropriate.

Finally, the nature of the high-speed National Research and Education Network (NREN) has been frequently misunderstood. In other proposed legislation, NREN has been described in a way that might suggest that it is a federal construction project or federal utility that would eventually compete with the common carriers. Nothing could be further from what is proposed. Therefore, it is important that any legislation mandating establishment of the NREN provide a careful description of what it really is and avoid any implications of what it is not.

I am happy to conclude that we find S. 343, as amended, to be quite consistent with each of these principles. S. 343, as amended, states the purposes of the HPCC program without overspecifying the details. It carefully avoids assigning coordinating responsibilities to any specific agency, leaving this matter to the President and thus preserving the flexibility essential to implement this dynamic program. Finally, as the result of cooperative effort by our staff, the description of the NREN in S. 343 accurately reflects what the Administration has proposed.

There are only two provisions in S. 343 with which we are not in full agreement. First, although we believe that the provision on collaborative consortia (Sec. 6(b)) would be beneficial to promote industrial involvement, it is not necessary since such collaborative efforts are already in existence and included within the HPCC program. Secondly, the word "all" in Sec. 5(b) should be deleted to avoid any possible confusion, since collaboration with "all" potential users is clearly impossible. The Office of Management and Budget advises that there is no objection to the submission of this letter to Congress from the standpoint of the President's program.

I appreciate your support for the President's initiative.

Sincerely,

A. ALLAN BROMLEY,
Director.

CHANGES IN EXISTING LAW

In compliance with paragraph 12 of rule XXVI of the Standing Rules of the Senate, the Committee notes that no changes in existing law are made by the bill, S. 343, as reported.

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